

U.S. Risk for Avian Influenza Due to an Outbreak in Mexico

April 1995

Executive Summary

In January 1995, a highly pathogenic avian influenza (HPAI) virus strain of unknown origin was confirmed in chickens in two Mexican states. The outbreak has raised concern about the risk that avian influenza (AI) in central Mexico may pose for the U.S., especially in light of the large economic costs of the last U.S. HPAI outbreak in 1983-1984. Adjusted for inflation, losses to producers and increased costs to consumers resulting from the 1983-1984 outbreak would today equal approximately \$85 and \$490 million, respectively. The APHIS' 1983-1984 eradication costs would also equal approximately \$85 million today.

The purposes of this report are: 1) to provide information on AI, the avian influenza virus (AIV), and the outbreak in Mexico; and 2) to assess the relative likelihood of either a nonpathogenic or a highly pathogenic AIV being introduced into U.S. poultry by any one of the possible sources of AIV from Mexico.

Rankings of relative likelihoods were determined by considering four factors for each possible source: 1) history of AIV transmission; 2) type of transmission possible or likely (biological vs. mechanical); 3) amount of contact with Mexican AIV and with U.S. poultry (or their environments); and 4) quantity of the possible source that may be entering the U.S.

The outbreak of AI in Mexico creates some risk for the introduction into U.S. poultry of a highly pathogenic or potentially highly pathogenic AIV. The sources most likely to spread AIV from Mexico to the U.S. are humans, motor vehicles (trucks), smuggled live poultry, and smuggled ratites. The risk of an AIV introduction associated with wild birds, including migratory

waterfowl, does not appear to have increased due to the outbreak in Mexico.

The risk of AIV introduction due to all of the possible sources associated with the outbreak in Mexico appears to be smaller than the ongoing risk of AIV introduction presented by wild birds not associated with the Mexican outbreak. This ongoing risk for U.S. poultry exists due to the reservoir of AIV circulating in wild birds, particularly migratory waterfowl. Domestic poultry most likely to become infected from this AIV reservoir are open-range birds, backyard flocks, hobby flocks, or other birds kept under conditions which might allow contact with wild birds or with an environment contaminated by such birds.

Biosecurity is the key to preventing an AIV introduction from Mexico. Efforts should be focused on preventing contact between poultry and humans who might have been in Mexico recently. Premises located in California or Texas may be at greatest risk for such human contact, as well as for direct or indirect contact with trucks or smuggled birds moving into the U.S. Thus, biosecurity should be emphasized in those states, as well as anywhere else that such types of contact may occur.

Issues related to AI surveillance were not addressed in this report. Due to the ongoing nature of the AI risk, however, a comprehensive assessment of such activities is warranted. The objective of the analysis should be to determine what, if anything, must be done to assure the earliest possible detection of a low pathogenic H5 or H7 AIV infection in U.S. poultry at the smallest possible cost.

I. Background

In May 1994, avian influenza (AI) was diagnosed in commercial poultry in central Mexico. In January 1995, a highly pathogenic AI (HPAI) virus strain of unknown origin was confirmed in two Mexican states. The outbreak has raised concern about the risk that AI in Mexico may pose for the U.S., especially because of the large economic costs of the last U.S. HPAI outbreak.

The last HPAI outbreak in the U.S. began in Pennsylvania in 1983. Before the outbreak ended in 1984, restrictions were placed on 20 counties in 4 states and nearly 17 million birds were depopulated. The affected area had produced about 4 percent of the broilers and 7 percent of the turkeys sold in the U.S.

Adjusted for inflation, losses to producers and increased costs to consumers resulting from the 1983-1984 outbreak would today equal approximately \$85 and \$490 million, respectively. The APHIS' 1983-1984 eradication costs would also equal approximately \$85 million today. The actual economic impact of a 1995 HPAI outbreak would depend upon such factors as: whether commercial production was affected, where the outbreak took place, how widespread the outbreak became, and what trade restrictions were imposed by foreign governments.

To determine what risk, if any, the AI outbreak in Mexico poses to the U.S. poultry industry, an understanding is needed about AI, the avian influenza virus (AIV), and the outbreak in Mexico. The purposes of this report are: 1) to provide information on AI, the AIV, and the outbreak in Mexico; and 2) to assess the relative likelihood of either a nonpathogenic or a highly pathogenic AIV being introduced into U. S. poultry by any one of the possible sources of AIV from Mexico.

The Disease

Avian influenza is caused by an influenza A virus, similar to that which can cause disease in humans, horses, pigs, and other mammals. The disease in chickens, turkeys, guinea fowl, ducks, and other migratory waterfowl can range

from an asymptomatic infection to an acute, fatal disease. The incubation period is usually 3 days or less and resulting signs or lesions can be quite variable. Signs may include decreased activity and egg production, respiratory signs, edema of the head and face, and diarrhea. The most severe gross lesions are generally characterized as congestive and hemorrhagic.

Survival and Transmission of Virus

Survival of AIV is best under moist and cool conditions. The presence of organic material is protective to the virus, which has been shown to survive for as long as 105 days in liquid manure. Virus has also been recovered from surface water in which waterfowl were present. Although the virus has been shown to survive in distilled water for at least 60 days at 28°C and 91 days at 4°C, and estimated to survive for 126 days or more at 17°C, the length of virus survival in surface water has not been established. In general, AIV survival decreases as pH becomes less neutral and as temperature or salinity increases. The virus is readily inactivated by common detergents and disinfectants.

Avian influenza virus replicates in both the respiratory and digestive tract of birds, thus virus is shed in both feces and respiratory secretions. Length of shedding has not been well established, but ducks have been shown to shed virus for up to 30 days.

Transmission of the virus may occur directly through contact with an infected bird, or indirectly through contact with contaminated fomites such as feed, water, equipment, cages, insects, or motor vehicles. Transmission has been associated with, but is not limited to, live bird markets, haulers, dealers, and auctions. Humans are often implicated in flock-to-flock spread through movement of contaminated clothing, footwear, or other fomites. Experience from the 1983-1984 outbreak suggests that even people coming within a short distance of an infected flock may become contaminated, presumably via airborne spread.

AI vs. Highly Pathogenic AI

Avian influenza virus is characterized by two surface antigens, hemagglutinin (HA) and neuraminidase (NA), of which there are 14 and 9 subtypes, respectively. Two of the HA subtypes, H5 and H7, have been associated with the highly pathogenic form of avian influenza in poultry. While many H5 and H7 subtypes never become highly pathogenic, a nonpathogenic strain of H5 or H7 virus in chickens may be capable of becoming highly pathogenic at any time. Although the loss of defective interfering particles (subgenomic RNAs) via an unknown mechanism is also required, a single point mutation in the HA gene can transform an avirulent (nonpathogenic) strain of AIV into a virulent (HPAI) strain.

The USDA:APHIS defines an influenza A virus as highly pathogenic AIV if it meets one of the following criteria: 1) kills at least 6 of 8 experimentally-inoculated susceptible chickens (4- to 6-weeks of age); 2) any H5 or H7 subtype that kills less than 6 of 8 chickens, but has an amino acid sequence at the HA cleavage site that is compatible with HPAI viruses; or 3) any other HA subtype (not H5 nor H7) which kills 1 to 5 chickens and grows in cell culture in the absence of trypsin.

Previous Outbreaks of Highly Pathogenic AI

Few documented outbreaks of HPAI in poultry have occurred in the last 20 years. The only countries known to have had more than one outbreak during that period are Australia (1975, 1985, 1992) and England (1979, 1991). The 1983-1984 U.S. outbreak, the first in this country since 1929, began in Pennsylvania and spread to three additional states. A low pathogenic H5N2 virus was isolated after clinically mild disease began in chicken (layer) flocks. During the initial months of the outbreak, flocks showed a moderate drop in production and mortality was usually less than 10 percent. Six months after the outbreak began, however, a highly pathogenic form of the virus was isolated. The HPAI was associated with 70 to 90 percent mortality in some broiler flocks.

Sources of Primary Infection

In general, four sources of primary infection in domestic poultry have been considered: 1) wild birds; 2) other species of domestic poultry; 3) exotic captive birds; and 4) other mammals.

Wild birds, primarily waterfowl, historically have been implicated in avian influenza outbreaks. Surveillance of waterfowl and shorebirds has shown that a large reservoir of influenza virus does exist in such birds, as antibodies to virtually every antigenic subtype of AIV have been detected. The source of the initial H5N2 infection in 1983 is unknown, but waterfowl have been suspected. Indeed, although H5N2 could not be isolated from over 1,000 wild ducks or geese sampled in the Pennsylvania outbreak area, over 25 percent of almost 700 such birds tested serologically for antibodies against H5 were positive. Testing of gulls in the Pennsylvania outbreak area found no H5N2 in over 200 birds, although H5N1 and H11N1 viruses were isolated from ring-billed gulls in the area. So while there was no evidence that the highly pathogenic virus originated directly in wild birds, it was deemed plausible that waterfowl were the original source of the virus and that the virulent strain of H5N2 was probably derived from the avirulent strain.

In Minnesota, close spatial and temporal relationships have been observed between breeding migratory waterfowl and outbreaks of AI in turkeys. It has been hypothesized that the virus may replicate most efficiently in the intestinal tract of juvenile waterfowl and that the feces of such birds are a likely source of significant quantities of virus.

It is not known if waterfowl can be infected by an AIV that has replicated in domestic poultry. Experimental inoculation by various routes of both the highly pathogenic and nonpathogenic 1983 Pennsylvania virus caused no detectable signs of disease in ducks. Researchers concluded that the virus did not replicate efficiently in ducks (based on infrequent recoveries of virus from feces or trachea) and that it had been sufficiently modified by replication in chickens to alter its

host specificity. During an outbreak of HPAI (H5N8) in turkeys in Ireland in 1983, a closely related HPAI virus was isolated from apparently healthy commercial ducks on an adjacent farm. Although the ducks may have acquired the virus from the turkeys, there is some evidence that they acquired the virus from wild birds.

While relatively few passerine birds have been documented to carry the AIV, it is unclear whether passerine birds tend not to carry the virus or have not been as widely tested. Testing of several hundred lots of passerine birds being imported into the U.S. from 1982 through 1994 has found AIV, mostly H3 and H4 subtypes, in a relatively small number of birds. Some H7 has also been found, but H5 has not.

The importance of the other three sources of primary infection (other domestic poultry, exotic captive birds, and other mammals) is less clear. Spread from one species of domestic poultry to another, probably through mechanical spread of virus, has been documented. Exotic captive birds have never been documented as a source of infection for domestic poultry, although ratites have on several occasions been found infected with H5 or H7 viruses. Surveillance of psittacine birds from around the world that were quarantined for importation into the U.S. from 1982 through 1994 produced primarily AIV isolates of subtypes H3 or H4, but no H5. Based on such findings, ratites may be more likely to be infected with an H5 or H7 virus than are psittacine birds. Influenza viruses (H1N1) of swine origin have been found in turkeys, but it is unknown how often such transmission of virus occurs.

Risk Factors for Infection of a Premises

Given the potential sources of primary infection of a flock and the means of transmission of the virus, there are factors that put some U.S. poultry at greater risk of AIV infection. Among those factors are biosecurity practices, type of premises, and location of premises.

Biosecurity Practices

Good biosecurity practices should reduce the risk of introduction and spread of AIV.

Although all poultry premises cannot implement optimum biosecurity, the ideal practices include:

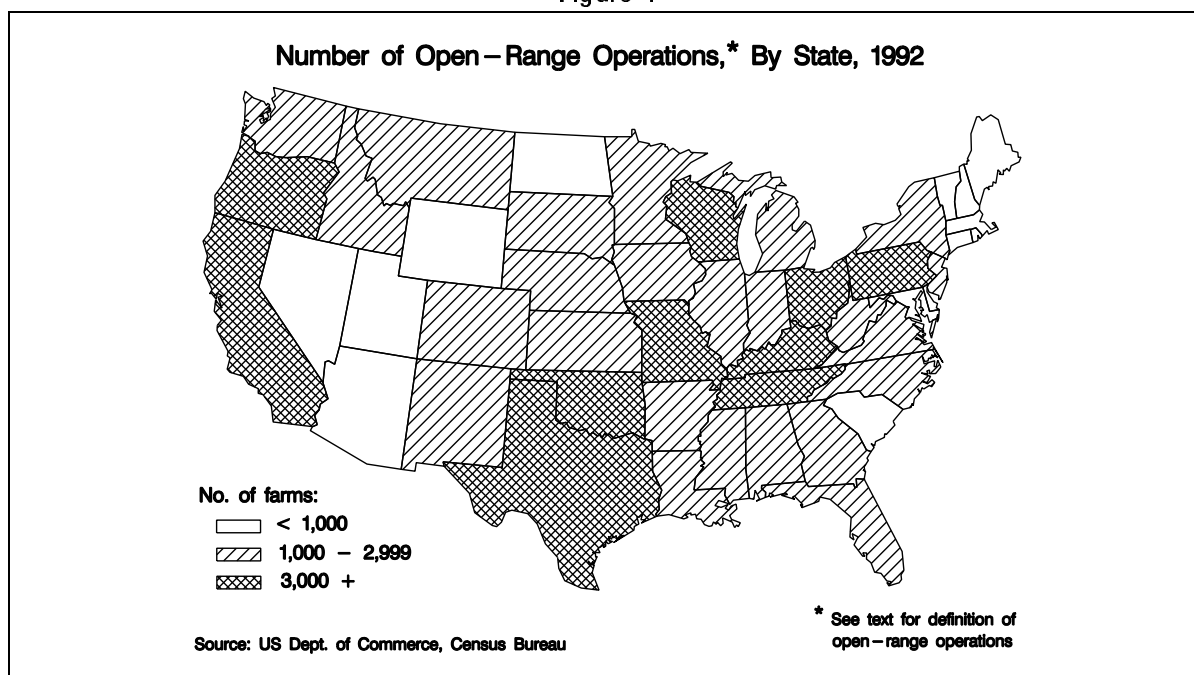
- managing poultry in an "all-in, all-out" style
- removing all organic material and cleaning and disinfecting houses between flocks
- not allowing poultry to come into contact with stored equipment or trash
- keeping other animals, such as pets, wildlife, and livestock, out of contact with poultry
- maintaining locks on poultry houses and gates on all access roads
- cleaning and disinfecting motor vehicles prior to coming onto the premises
- keeping pedestrian traffic to a minimum and allowing only necessary personnel into houses
- requiring clean coveralls and disinfected boots prior to entry
- in addition to clean clothing, requiring a shower prior to entering a house if the person has recently been in contact with other poultry
- thoroughly cleaning and disinfecting any equipment used within a poultry house

Type of Premises

In general, poultry that are exposed to wild birds, particularly waterfowl, are at greater risk for AI than those with no such exposure. Exposure is likely to be greater in open-range operations, backyard flocks, or hobby flocks. The frequent occurrence of AI in open-range turkeys in Minnesota is evidence of the risk of such exposure. Confined poultry can also be exposed to waterfowl, especially if a pond or other waterfowl habitat is located on the premises. The Pennsylvania outbreak began in confined chickens, but there was a history of waterfowl on the premises.

The exact numbers of open-range operations, backyard flocks, and premises with confined flocks and waterfowl habitat, are unknown. An estimate of the number of open-range operations can be made by assuming that all premises with less than 50 chickens, and those

Figure 1

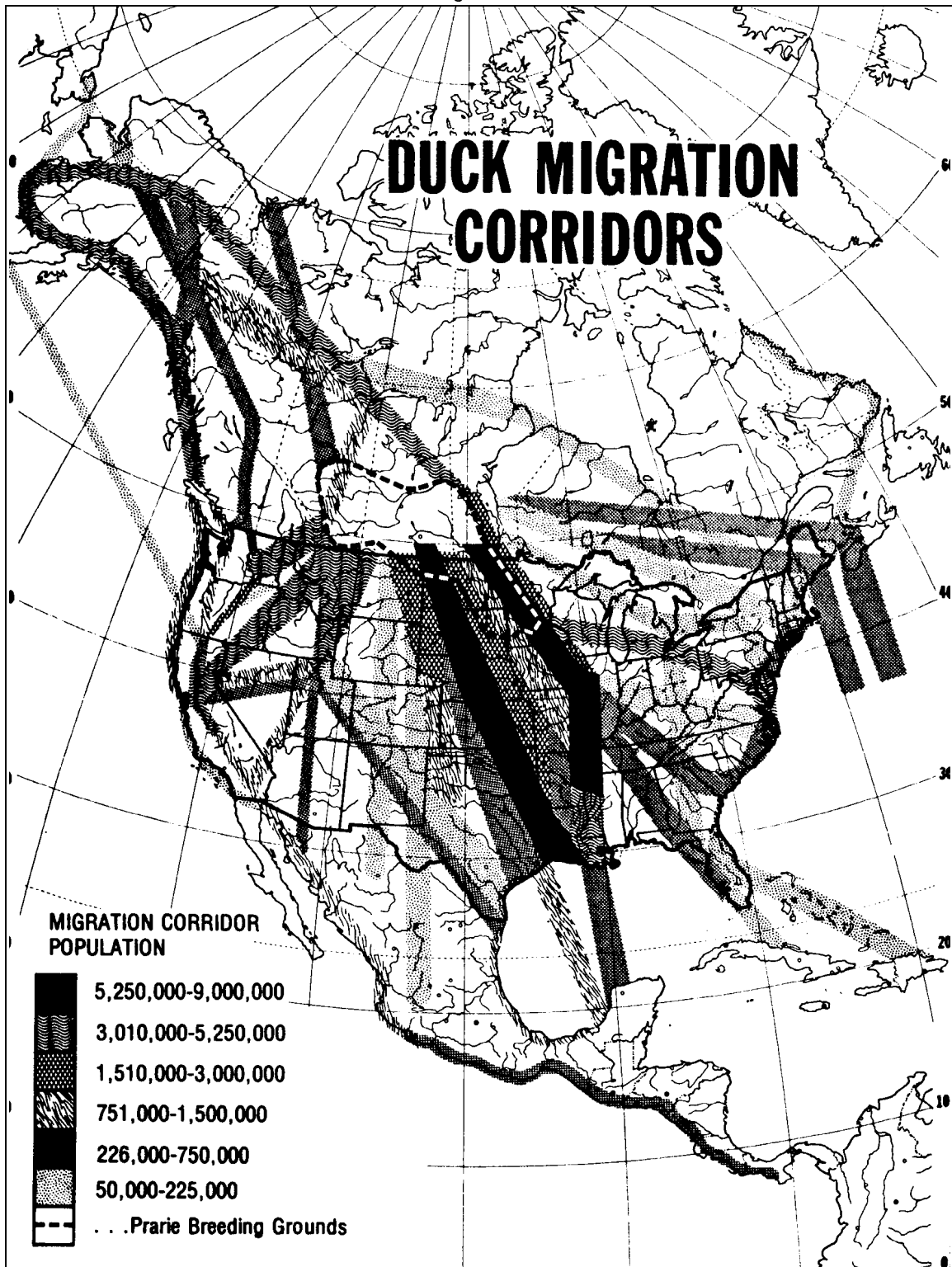


with ducks, geese, or other poultry (not turkeys), are open-range operations. Under this assumption, Texas has the largest number of open-range operations (9,064), followed by Missouri (5,067) and California (4,524) (Figure 1). The top five broiler-producing states (AR, GA, AL, NC, MS) all have more than 1,000, but less than 3,000, open-range farms.

Location of Premises

Because migratory waterfowl are a reservoir for AI viruses, flocks located in waterfowl flyways, or migration corridors, may be at greater risk for AIV introduction. Although almost any area of the U.S. may have waterfowl present, exposure to waterfowl is likely to be greatest along migratory flyways or near breeding or wintering areas. The largest number of ducks and geese fly along corridors associated with the Mississippi River and the Central Plains (Figure 2).

Figure 2



(Source: Bellrose, F.C. 1976. Ducks, geese & swans of North America. Stackpole Books, Harrisburg, PA.)

II. The Avian Influenza Outbreak in Mexico

In May 1994, the Animal Health General Directorate of Mexico was officially informed that AI viruses had been isolated from poultry (chickens) in the Mexican states of Queretaro, Hidalgo, and Mexico. All isolates were H5N2 and of low pathogenicity. Additional surveillance subsequently detected virus in the states of Aguascalientes, Guanajuato, Guerrero, Jalisco, Morelos, Puebla, Veracruz, and the Distrito Federal. Serological evidence of AI was also found in eight other states.

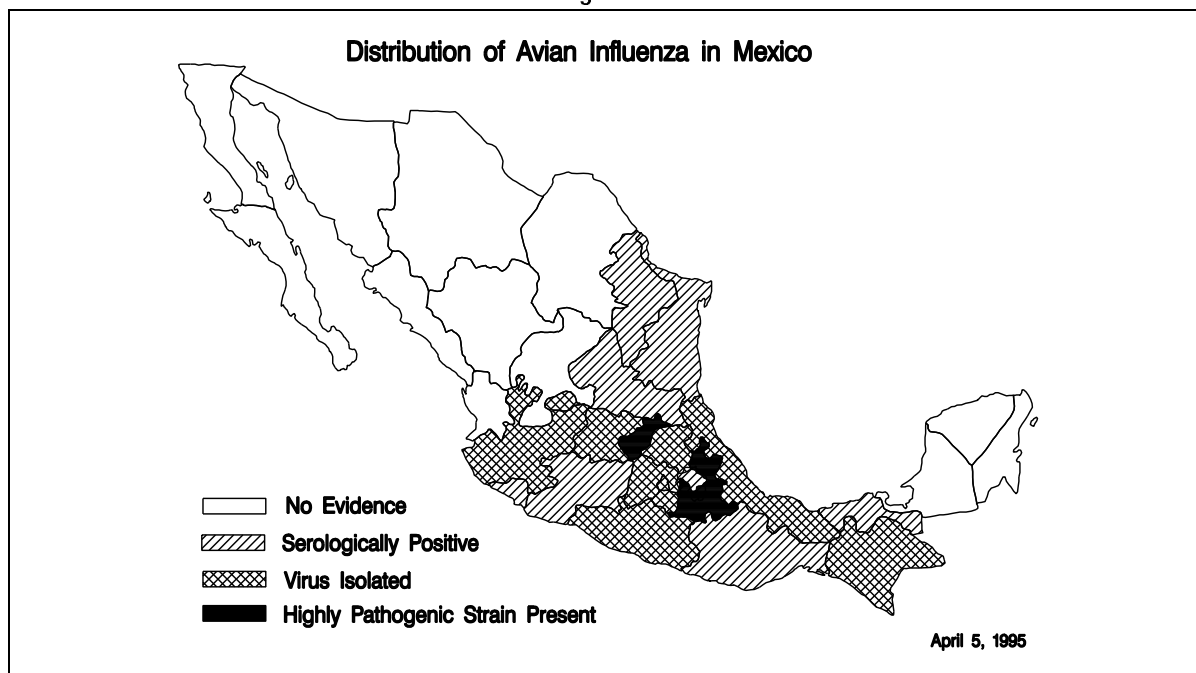
In January 1995, highly pathogenic H5N2 was found on three commercial laying farms in Puebla. Quarantines were placed on the premises and all farms in the area were surveyed to determine the extent of spread. Highly pathogenic AI was subsequently found in a breeding flock in Queretaro, resulting in the depopulation of 11,000 birds, and medium pathogenic virus (killed between 2 and 5 of 8 inoculated chickens) was discovered in Jalisco.

In response, the Animal Health Emergency System was activated with an objective of control and eradication. Some depopulation of

birds has taken place on medium or highly pathogenic AI-infected premises. Due to lack of funds for indemnity, however, control of the outbreak is being attempted primarily using surveillance, vaccination, and quarantine. Movement of birds from known infected areas is being restricted. Vaccination requires an official permit and is being used only in states that have identified highly or medium pathogenic AI. The vaccination priorities are, in descending order, grandparent and broiler breeders, table egg layers, and broilers.

Since January, AIV has been isolated from chickens in the state of Chiapas, bringing to 12 the total number of states in which AIV has been isolated from poultry (Figure 3). As of April 5, 1995, a total of 74 premises had been affected in the three states that have reported highly or medium pathogenic AI (Puebla, Queretaro, and Jalisco). Of those, 41 premises were under quarantine and 33 had been depopulated. The premises had approximately 32.8 million birds affected and 18.2 million birds depopulated. In addition, at least 59 million birds had been vaccinated in those states.

Figure 3



III. Spread of Avian Influenza Virus from Mexico to U.S. Poultry

Due to the reservoir of AI viruses present in migratory waterfowl and other wild birds, U.S. poultry is normally at some risk for the introduction of AIV. However, poultry operations with exposure to some of the possible sources of virus from Mexico may now be at somewhat higher risk than usual.

The possible sources of virus from Mexico were assigned qualitative rankings of low, medium, or high, with regard to their relative likelihood of being involved with the spread of Mexican AIV to U.S. poultry (Table 1). A ranking of "high" means that the likelihood of that source being involved is probably higher than that of other sources. Such a ranking does not mean that there is a high likelihood that the source will be involved in spreading AIV from Mexico to the U.S. Rankings were determined by considering four factors for each possible source: 1) history of AIV transmission; 2) type of transmission possible or likely (biological vs. mechanical); 3) amount of contact with Mexican AIV and with U.S. poultry (or their environments); and 4) quantity of the possible source entering the U.S. Some of the sources are discussed below.

Humans

One potential source of virus is human beings. Although limited replication of some AI viruses in humans is possible, biological transmission from humans has not been demonstrated. However, because the AIV can survive for long periods of time in organic material such as manure, persons whose footwear or clothing is soiled are a possible source of mechanically transmitted virus. Humans are believed to have been one of the primary means of spread of AI during the 1983-1984 outbreak.

Any person that has had recent contact with poultry in Mexico is of concern. Poultry industry workers (i.e., people who have close contact with chickens) are of particular interest. It was estimated that the annual average number of temporary Mexican workers in the U.S. was 396,000 in 1990. Based on remittances (money sent home by migrant workers) processed through the national banking system in Mexico, four of the five top migrant-originating states in Mexico are currently infected with AI (Figure 4). Although there is less information about where

Figure 4

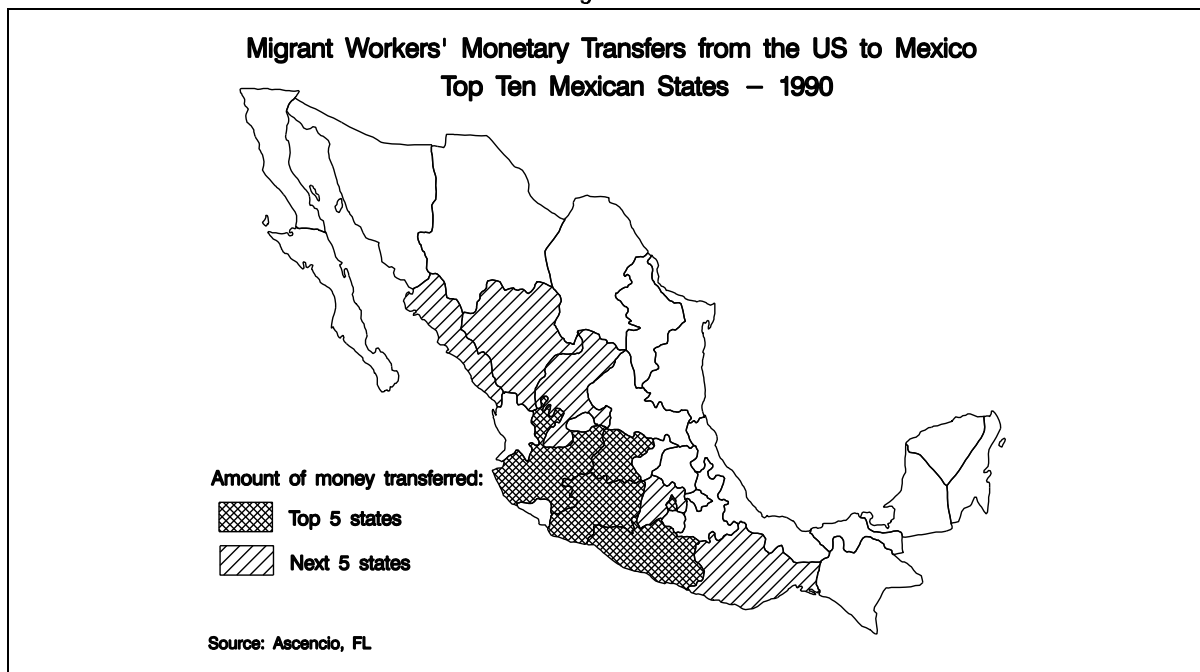


Table 1. Likelihood of Spread of Avian Influenza Virus¹ from Mexico to U.S. Poultry				
Possible Source of Virus		Mode	Comment	Ranking²
Humans	poultry workers	M	contaminated clothing or footwear; potential for direct movement from Mexico to U.S. poultry	high
Motor vehicles	trucks	M	increased traffic from Mexico	medium
Live poultry	chickens, turkeys, domestic ducks	M / B	unlikely to cross border without quarantine	low
	fighting cocks	M / B	smuggled birds could enter U.S. with infection	medium
Exotic captive birds	psittacine birds	M / B	unlikely to be soiled with feces; such birds never shown to be cause of AI outbreak; H3 or H4 most commonly found	low
	ratites	M / B	smuggled birds or eggs could be infected with H5	medium
Wild migratory waterfowl	ducks, geese	M / B	unlikely direct contact with AIV in Mexico and poultry in U.S.; no evidence of AIV from poultry replicating in wild ducks; few mallards or Canada geese in Mexico	low
Other migratory birds	passerine birds	M / B	AIV not isolated from feet of such birds on AI premises in '83-'84; can carry some types of AIV; AIV not isolated from such birds associated with AI premises in '83-'84	low
	shorebirds, wading birds	M / B	direct contact in Mexico probably low; migration mostly along Pacific Coast or local in nature	low
	gulls	M / B	unlikely direct contact with AIV in Mexico; AIV not isolated from such birds associated with AI premises in '83-'84	low
	raptors	M / B	some species may have exposure to AI in Mexico, but exposure to U.S. poultry unlikely; no AIV documented in raptors	low
Other animals	rodents	M / B	AIV not isolated from feet or lungs of rodents on AI premises in '83-'84	low
	swine, equine	M / B	unlikely to come into contact with U.S. poultry; transmission of H5 from swine to poultry might be possible; contact with U.S. poultry unlikely	low
Poultry products	eggs, meat, offal, feathers	M	limited importations and unlikely exposure to U.S. poultry	low
Insects	flies	M	sufficient movement unlikely	low
Equipment, cages		M	cleaned prior to import; low volume crossing into U.S. due to limited poultry trade with Mexico	low
Feed, supplies		M	importation unlikely	low
Air / wind		M	very unlikely over long distances	low
M = mechanical, B = biological 1 - Includes any kind of AIV (low, medium, or highly pathogenic) involved in the current Mexican outbreak 2 - Rankings are qualitative and relative to each of the other sources listed; rankings are not necessarily indicative of the actual likelihood of a given source being involved in the transmission of AIV from Mexico to a U.S. poultry flock.				

migrant Mexican workers may be located in the U.S., many of them are presumably in California and Texas, where over 35 percent of an estimated 3 million other seasonal agricultural migrants (of all origins) and their dependents reside.

In addition to poultry workers, any traveler that might have close contact with Mexican poultry presents a risk for mechanical transmission of AI. While the greatest risk would be from persons that have direct contact with U.S. poultry upon their return from Mexico, some risk probably also exists for environmental contamination by people returning from Mexico. Such contamination could lead to infection of backyard flocks, hobby flocks, or live bird markets.

Migratory Birds

Another source of virus from Mexico could be migratory birds, including waterfowl. These birds could be a source of the Mexican AIV only if they were infected with virus that has replicated in domestic poultry or if they were able to

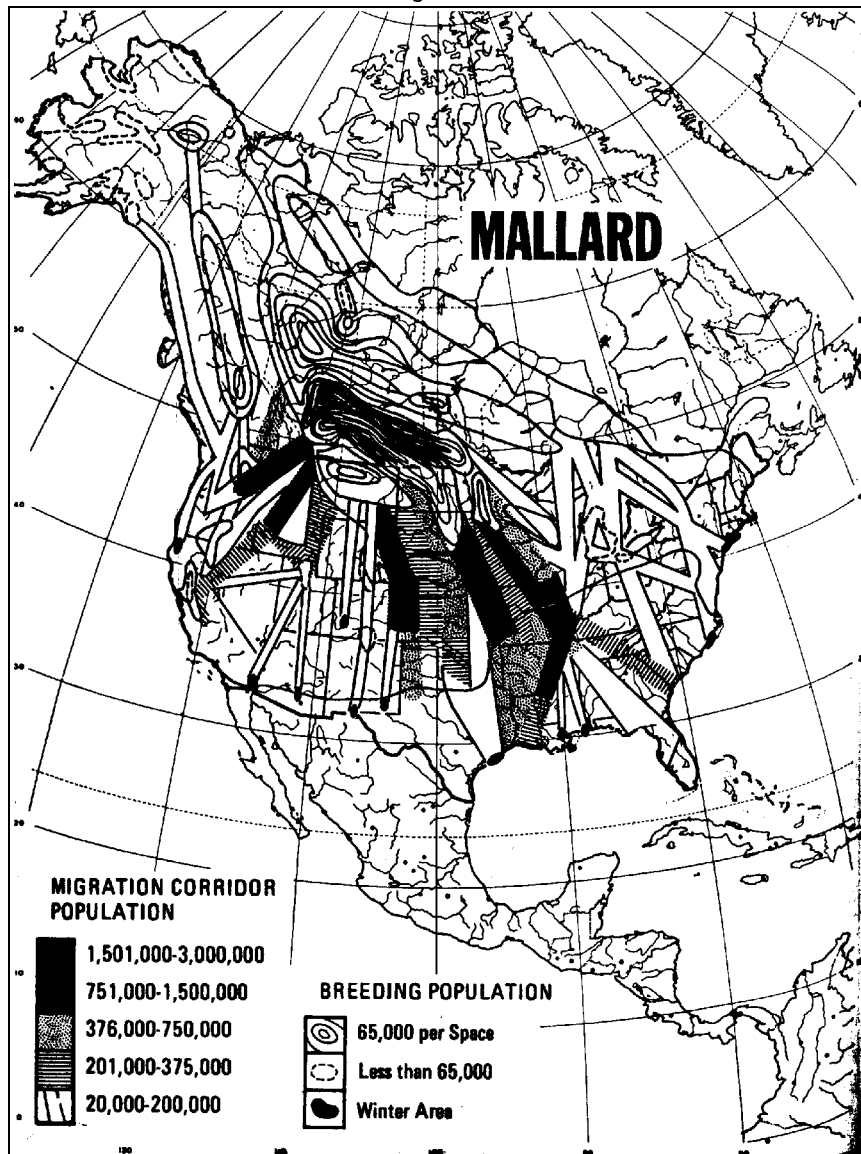
mechanically transmit viable virus. There is no significant evidence of either occurring naturally, nor has either been demonstrated experimentally. Of course, the potential always exists for migratory birds to be a primary source of an AIV that is not related to the outbreak in Mexico, as such birds are a reservoir for AIV.

Although evidence is lacking that migratory birds are a potential source of AIV from Mexico, information about the migratory patterns and range of such birds can help to define the types of birds that could be of possible concern and the areas of the U.S. that could be at higher risk. Breeding areas are species specific, but shorebird species generally migrate to subarctic areas as do some waterfowl. A number of waterfowl species breed in the upper midwest of the U.S. in close proximity to some U.S. poultry.

A number of species of migratory birds winter in south central Mexico or migrate through the region (Table 2). Except for some passerine species, the general migration pattern of most species from central Mexico is limited to the

Table 2. Migration Behavior: Birds that Winter In or Migrate Through Central Mexico			
Bird Type	Wintering Area in Mexico	Migration Patterns from Mexico	Examples of Birds that Migrate from Central Mexico
Waterfowl	Inland and along coastal areas	Primarily Pacific Coast or Central Flyway, staying west of Arkansas; some breed within U.S.	White-fronted goose, lesser snow goose, teal, shoveler, pintail
Passerine	Inland and coastal; not necessarily near wetlands	More likely to migrate on broad fronts with little fidelity to specific routes	Blackbirds, white-winged dove, band-tailed pigeon, mourning dove
Shorebirds (wetland and prairie types)	Primarily coastal or migrating through	Generally follow the Pacific Coast to find food in marine environments or migrate nonstop to points north of U.S.	Yellowlegs, plovers, American avocet, killdeer, godwits, long-billed dowagers, sandpipers
Gulls	Much of Mexico for some species	Selected species migrate to many areas of the U.S.	Herring, ring-billed, laughing, Bonaparte's, Franklin's, and Heermann's gull
Long-necked and long-legged wading birds	Northern Mexico for some species	Egrets tend to be local or move in shorter segments; cranes do not migrate as far south as central Mexico (current outbreak area)	none
Raptors	Much of Mexico for some species	Selected species may migrate to broad areas of the U.S.	Turkey vulture, northern harrier, red-tailed hawk, Cooper's hawk, peregrine falcon

Figure 5

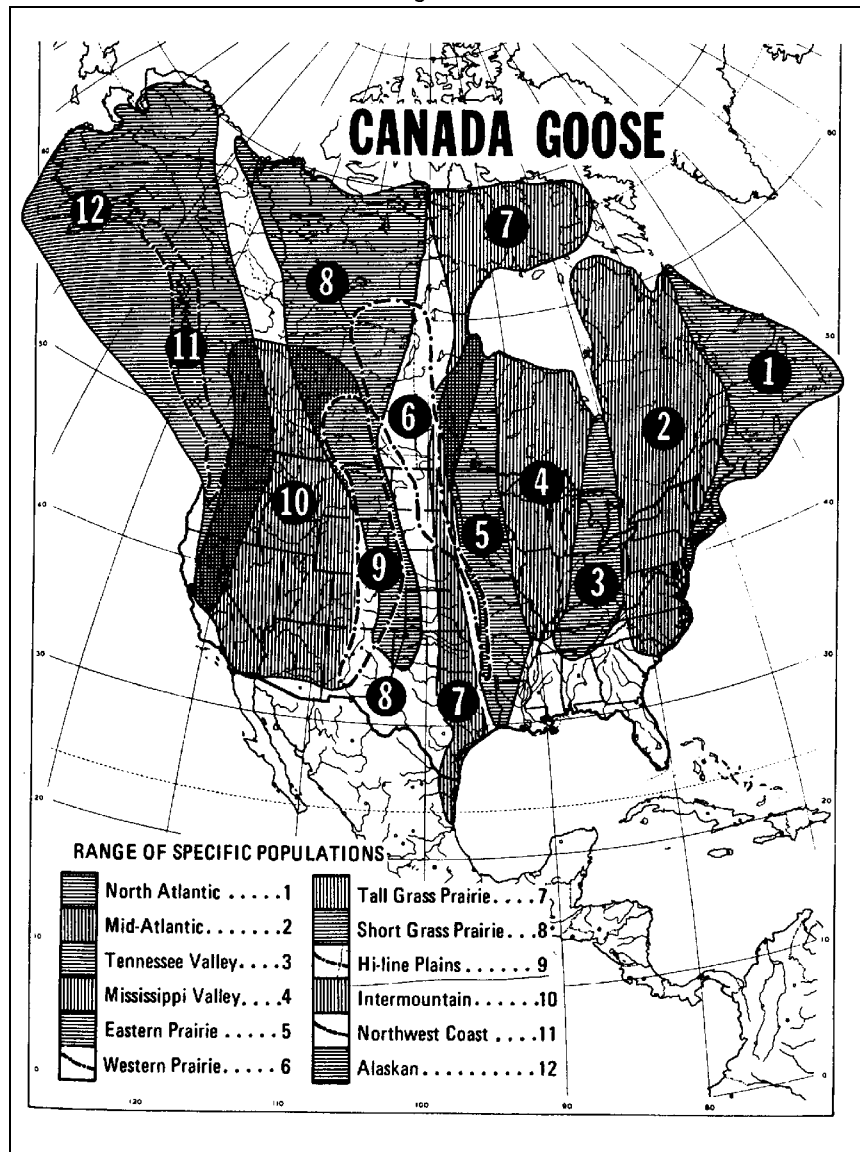


(Source: Bellrose, F.C. 1976. Ducks, geese & swans of North America. Stackpole Books, Harrisburg, PA.)

western U.S., primarily west of the large poultry areas in western Arkansas. Behavior during migration is also variable. Some shorebirds migrate in one step of 2,000 miles, while others will stop to eat and rest in coastal areas. Waterfowl and some wading birds tend to exhibit homing fidelity for breeding grounds, migration routes, and wintering areas, while passerine birds tend to be more widely dispersed. It is relevant that very few mallards, the most common ducks in the U.S., migrate into Mexico (Figure 5). Likewise, relatively few Canada geese winter in Mexico and none range far enough south to be in the current outbreak area (Figure 6).

Although some of the raptors that are indigenous to the U.S. are migratory and may winter in Mexico, there is no evidence that any of these birds can serve as a biological vector of AIV. The likelihood of raptors having contact with both Mexican and U.S. poultry and serving as mechanical vectors of virus over long distances is probably quite low. The turkey vulture, which has a wide range and may winter in Mexico, is

Figure 6



(Source: Bellrose, F.C. 1976. Ducks, geese & swans of North America. Stackpole Books, Harrisburg, PA.)

known for its ability to detect poultry carcasses. The black vulture, which occurs primarily in the southeast U.S., does not appear to be migratory. The northern harrier winters in the U.S. and throughout Mexico into Central America. Cooper's hawks also winter in central Mexico. Other hawks that could come into contact with AI in Mexico include the red-tailed hawk, a fairly common species that has a breeding/wintering range that extends into the northern part of the infected area in Mexico, and the zone-tailed hawk, that primarily winters in Mexico and has a range that extends into the extreme southwestern U.S. Ospreys breed and winter throughout the U.S. and through Mexico

to Central America but prey primarily on fish. None of the eagles have ranges that extend into central Mexico. Several falcons, including the peregrine, merlin, and American kestrel, have migration behavior and wintering areas that include central Mexico. Peregrine falcons, also known as duck hawks, feed on waterbirds and are known to concentrate during the winter in areas where coots, teal, and pintails are found.

The migratory patterns of gulls vary greatly by species, but at least four species could migrate through central Mexico and to almost any part of the U.S. They are the herring, ring-billed, Bonaparte's, and Franklin's gull. Other species

that could migrate through Mexico have narrower ranges in the U.S., including the laughing gull (Atlantic Coast) and Heermann's gull (Pacific Coast). As with other migratory birds, there is no evidence that gulls could biologically acquire AIV that has replicated in domestic poultry. Mechanical transmission over long distances by such relatively slow-flying birds, including contact with both Mexican and U.S. poultry, appears unlikely.

Thus, while their relative likelihood of spreading AIV from Mexico is low compared to other possible sources, waterfowl appear to present a somewhat greater risk of virus transmission from Mexico than do other migratory birds. This conclusion is based on the locations of their wintering areas in Mexico and their breeding areas near U.S. poultry. The risk due to passerine birds is not well understood. Their large numbers, diffuse migratory behavior, and greater potential for direct contact with domestic commercial poultry may increase their potential risk. The extent of migration of some of the wading birds such as the egret indicates they may not be a problem. Shorebird migration routes and estuarine/marine preferences would not likely put them in contact with either Mexican or domestic poultry. Wading birds do not appear to migrate far enough into Mexico to currently present any risk of transmission of virus.

Live Poultry and Other Birds

The movement of live avian species into the U.S. from Mexico has been restricted for many years. U.S. Department of Commerce data for the last 5 years indicate that no live poultry has legally entered the U.S. from Mexico. A few hundred other birds, probably ratites, were imported in 1992 and 1993. Because the amount of live poultry and other birds imported legally from Mexico is very small, and because live birds imported into the U.S. are required to be quarantined, smuggled birds are the real concern relative to AIV.

Incentive for smuggling is likely to be greatest for birds such as fighting cocks. Although the number of fighting cocks that are successfully smuggled into the U.S. could be small, such birds are likely to have had contact with other birds at risk for AI (such as backyard poultry flocks). Some fighting cocks in northern Mexico (Tamaulipas) have been found serologically positive for H5N2. Thus, such birds must be considered to have the potential for biological transmission and are therefore ranked as having a medium relative likelihood of being a source of AIV from Mexico.

While many exotic captive birds, including ratite and psittacine birds, can be infected with AIV, there are no known instances of these birds being the source of an outbreak among poultry. As with waterfowl, neither ratites nor psittacines have been known to acquire AI from infected poultry. However, because of their relatively frequent infections with H5 virus, smuggled ratites were ranked as having a medium relative likelihood of being a source for spread of H5 from Mexico.

Products from Poultry and Other Birds

Few poultry or other bird products have entered the U.S. from Mexico in recent months. Some ratite eggs have been imported, but no poultry eggs have entered from Mexico in the last 5 years. All ratites eggs go into quarantine until 30 days after the last chick has hatched and testing for hemagglutinating viruses is performed. The only other bird products that entered from Mexico in 1994 were feathers - cleaned and disinfected (311 kilograms) and bird skin - part with feather/ down (216 kilograms). Based on the relatively high reported value of the bird skins (\$23 per kilogram), they are not likely to have come from poultry. Given the low number of products, the manner in which they are handled, and the unlikely contact with U.S. poultry premises, the relative likelihood of spread of AIV associated with Mexican bird products appears to be low.

Trucks

The concern about truck traffic entering the U.S. from Mexico is primarily related to external contamination. Certain motor vehicles, such as poultry or other agricultural trucks, are of special interest because of a greater potential for internal as well as external contamination. In practice, trucks crossing the U.S./Mexico border are required to be visually clean, although true disinfection cannot be guaranteed. Most truck trailers are not likely to be inspected internally, although any trailer capable of carrying live animals or poultry would be ventilated enough to allow some internal visual inspection from the exterior.

An indicator of overall truck flow from Mexico to the U.S. was derived from data on the fees that the USDA:APHIS collects for the inspection of trucks crossing the border. In fiscal year 1994, APHIS collected a \$2.00 fee for each of 616,544 individual truck crossings. An additional 13,480 trucks paid \$40 for an annual decal. Assuming that each truck with a decal made at least 20 crossings, the estimated total number of truck crossings from Mexico would have been approximately 886,000. Information is not kept about what is being carried in each truck, where the truck originated in Mexico, or its U.S. destination.

Data on international surface trade, compiled by the U.S. Department of Transportation's Bureau of Transportation Statistics, were examined to better assess the amount of agricultural truck traffic that may be entering the U.S. from AI-infected states in Mexico. The data include surface freight flow (truck and rail) of U.S. exports to Mexico and imports from Mexico. Despite some limitations¹, export data were chosen for analysis rather than import data. This was because the Mexican state of origin for imports into the U.S. is not currently collected, but the Mexican state of destination for exports from the U.S. is collected. In order to use export

data as an indicator of flow from specific states in Mexico to specific U.S. states, an assumption must be made that trucks traveling to Mexico eventually return to their U.S. state of origin.

Data on shipments to Mexico of live animals and of products of animal origin (excluding milk) were chosen for analysis because of the potential for vehicles carrying such shipments to have contact with Mexican poultry, poultry products, or poultry premises. No specific data on shipments of poultry or poultry products were available. Data for April through September, 1994, were summarized (Tables 3 and 4). Slightly over 1 percent of the live animal shipments and less than 0.1 percent of the animal product shipments were reportedly destined for HPAI states in Mexico. Almost 29 percent of the live animal shipments and almost 50 percent of the animal product shipments were destined for AIV-free states. However, 33 percent of the live animal shipments and over 10 percent of the animal product shipments had unknown destinations in Mexico.

Live animal shipments to HPAI states in Mexico were reported to originate in seven U.S. states (TX, IA, IL, MN, NE, WI, WY). Only Texas and Iowa reported more than one shipment to an HPAI state in Mexico (25 and 2, respectively). Texas also represented the predominate origin for shipments to low pathogenic AI states in Mexico (93.4 percent). Shipments of animal products to HPAI states in Mexico originated only in California and Texas. The great majority (87.5 percent) of the shipments of animal products destined for low pathogenic AI states in Mexico originated from California, Texas, and Arizona. An additional eight U.S. states (CO, FL, MD, MN, ND, NY, OR, TN) shipped some animal products to low pathogenic AI states in Mexico.

Although it may not be indicative of a real trend, an increasing number of shipments to Mexico is evident in the 6 months of data analyzed. There is a potential cause for concern if the outbreak in Mexico continues

¹ The reported origin within the U.S. and the reported destination state in Mexico may not be completely accurate. The origin within the U.S. may reflect the last place from which the commodity was moved before exportation. The destination in Mexico may reflect the importer's home of record, not the actual destination of the commodity.

Table 3. Shipments of Live Animals to Mexico, April - September, 1994						
Month	Avian Influenza Status of Destination State					
	Highly Pathogenic	Low Pathogenic	Serologically Positive	Free	Destination Unknown	Total
April	1	97	24	114	124	360
May	1	118	34	92	106	351
June	7	122	69	83	161	442
July	9	98	88	103	135	433
August	5	108	38	172	155	478
September	10	129	50	197	190	576
TOTAL	33	672	303	761	871	2,640

Table 4. Shipments of Animal-Origin Products¹ to Mexico, April - September, 1994						
Month	Avian Influenza Status of Destination State					
	Highly Pathogenic	Low Pathogenic	Serologically Positive	Free	Destination Unknown	Total
April	0	46	89	205	33	373
May	0	81	65	229	44	419
June	0	152	171	306	78	707
July	0	242	221	383	104	950
August	2	155	248	561	158	1,124
September	1	263	307	738	111	1,420
TOTAL	3	939	1,101	2,422	528	4,993

¹ Does not include milk or milk products.

and truck crossings from Mexico increase on an annual basis. Because we are assuming that trucks return to their origin, an increase in traffic in either direction will mean more trucks crossing into the U.S. from Mexico.

There are indications that such crossings are likely to increase. Avian influenza in Mexico may help create demand for replacement poultry that would lead to increased poultry-related traffic between the U.S. and Mexico. While the recent devaluation of the Mexican peso might tend to inhibit that demand, devaluation could increase U.S. demand for Mexican products. Thus, in the near term, a higher level of traffic between the U.S. and Mexico may be likely.

Other Sources

Although swine or equine could theoretically be mechanical or biological sources of AIV from Mexico, it is unlikely that sufficient contact with U.S. poultry would ever take place for such transmission to actually occur. There have been reports of clinical H5 infections of swine associated with the current AI outbreak in Mexico. It is possible, but has not been shown, that live swine with clinical infection could be a source of H5 virus capable of infecting poultry.

Rodents have not been shown to be a source of spread of AIV in previous outbreaks and are not a likely source in this case. Testing of mice and

rats located on premises with AI in Pennsylvania in 1983-1984 found no evidence of virus being carried either biologically or mechanically. No virus was isolated from the lung tissue of 269 mice or rats nor from the toes of 247 such rodents. In addition, the distance from the outbreak area in Mexico to the U.S. limits opportunities for rodents to have contact with virus in Mexico and with U.S. poultry.

Flies were implicated as a possible source of infection of some flocks in the outbreak in Pennsylvania and virus was isolated from house flies in 25 of 300 pools of insects collected on affected premises. In addition, virus has reportedly been isolated from flies associated with the outbreak in Mexico. Thus, mechanical transmission by flies may be probable under some conditions. It is probably unlikely, however, that flies would serve as a mechanical source for spreading virus from Mexico to the U.S., given the probable long time period between exposure to virus in Mexico and contact with U.S. poultry.

Avian influenza virus can be transmitted through the air over distances of a few meters. Airborne transmission was suspected in some cases of short distance spread in 1983-1984, and H5N2 virus was recovered from one high volume air sample (30,000 liters) taken 45 meters downwind from an affected premises. Transmission over longer distances, however, has not been shown and appears unlikely. The main impact of short distance airborne transmission of AIV may be through contamination of humans, motor vehicles, or equipment in the vicinity of an infected flock.

IV. Summary

Conclusions

The outbreak of AI in Mexico creates some risk for the introduction of a highly pathogenic or potentially highly pathogenic AIV into U.S. poultry. The sources most likely to spread AIV from Mexico to the U.S. are humans, motor vehicles (trucks), smuggled live poultry, and smuggled ratites (Table 1). The risk of an AIV introduction associated with wild birds, including migratory waterfowl, does not appear to have increased due to the outbreak in Mexico. That is, migratory waterfowl are not likely to expose U.S. poultry to any AIV currently found in Mexican poultry.

The magnitude of the risk of introducing AIV into U.S. poultry, presented by humans and other potential sources of AIV associated with the outbreak in Mexico, is difficult to assess. Although humans were ranked as "high" compared to other possible sources of virus from Mexico, the actual likelihood of humans transmitting AIV from Mexico to U.S. poultry does not appear to be high. Indeed, the additional risk of AIV introduction due to all of the possible sources associated with the outbreak in Mexico appears to be smaller than the ongoing risk of AIV introduction presented by wild birds not associated with the Mexican outbreak.

The ongoing risk for the introduction of AIV in U.S. poultry exists due to the reservoir of AIV circulating in wild birds, particularly migratory waterfowl. While this risk should be of some concern to all poultry producers, the domestic poultry most likely to become infected from this AIV reservoir are open-range birds, backyard flocks, hobby flocks, or other birds kept under conditions which might allow contact with wild birds or with an environment contaminated by such birds.

Recommendations

Because the Mexican AI outbreak creates some possible sources of AIV in addition to the wild bird reservoir, poultry premises with poor biosecurity are now at even greater risk for AI. Thus, biosecurity is the key to preventing an AIV introduction from Mexico. Efforts should

be focused on preventing contact between poultry and humans who might have been in Mexico recently. Premises located in California or Texas may be at greatest risk for such human contact and also for direct or indirect contact with trucks or smuggled birds moving into the U.S. Thus, biosecurity should be emphasized in those states, as well as anywhere else that such types of contact may occur.

Issues related to AI surveillance were not addressed in this report. Currently, live bird markets and auctions in the northeastern U.S. constitute the focus of AI surveillance by USDA:APHIS, in cooperation with the involved states. In addition, several states administer their own AI surveillance. Although an outbreak of HPAI in U.S. poultry would likely be detected even without current surveillance practices, the chance of detecting a low pathogenic H5 or H7 outbreak at an early stage is more uncertain. Given the ongoing nature of the AI risk, a comprehensive analysis of the entire range of AI surveillance activities in the U.S. is probably warranted. The objective of the analysis should be to determine what, if anything, must be done to assure the earliest possible detection of a low pathogenic H5 or H7 AIV infection in U.S. poultry at the smallest possible cost.

If you have questions, or would like copies of this report, please contact:

USDA:APHIS:VS
Centers for Epidemiology and Animal Health
555 South Howes, Suite 200
Fort Collins, CO 80521

Telephone: (970) 490-7800
FAX: (970) 490-7899